6-Axis Miniature Hexapod

HIGH PRECISION IN A SMALL PACKAGE

H-810

- Most compact standard Hexapod in the PI portfolio
- Travel ranges to 40 mm / 60°
- Load capacity to 5 kg
- Actuator resolution 40 nm
- Min. incremental motion to 0.5 µm
- Repeatability to ±0.1 µm

Reference-class 6-axis positioning system
Parallel-kinematic design for six degrees of freedom making it significantly more compact and stiff than serial-kinematic systems, higher dynamic range, no moved cables: Higher reliability, reduced friction

Direct drive with brushless DC motors (BLDC) and long-life ball screws
High precision, velocity and lifetime

Powerful digital controller, open software architecture
User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles).

H-810.xx1 includes C-887.11, 6D vector motion controller plus 2 additional servo axes. Options:

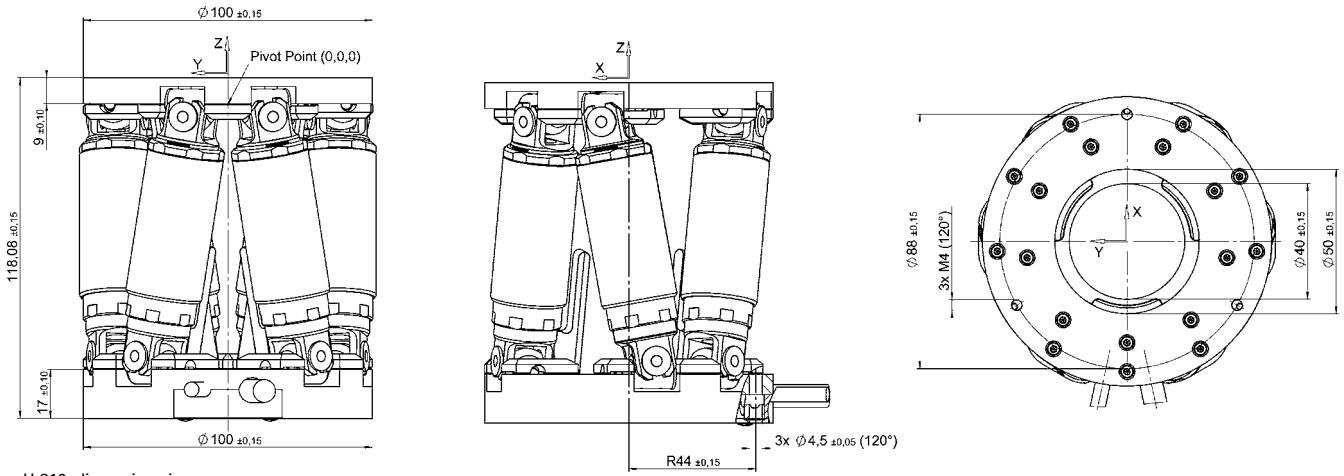
- Analog interfaces/photometer cards for visible light (F-206.VVU) or the infrared light range (F-206.iiU)
- F-206.NCU fast piezo nano-alignment system for alignment with nanometer precision

H-810.xx2 includes C-887.21 compact 6D vector motion controller

Fields of application
Research and industry. For micromanipulation, laser and optics alignment, biotechnology, tool control

	H-810.D1x	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y	±20	mm	
Travel range* Z	±6.5	mm	
Travel range* θ_X, θ_Y	±10	°	
Travel range* θ_Z	±30	°	
Single-actuator design resolution	40	nm	
Min. incremental motion X, Y	1	µm	typ.
Min. incremental motion Z	0.5	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	10	µrad	typ.
Backlash X, Y	3	µm	typ.
Backlash Z	0.5	µm	typ.
Backlash θ_X, θ_Y	15	µrad	typ.
Backlash θ_Z	75	µrad	typ.
Repeatability X, Y	±1	µm	typ.
Repeatability Z	±0.1	µm	typ.
Repeatability θ_X, θ_Y	±3	µrad	typ.
Repeatability θ_Z	±15	µrad	typ.
Max. velocity X, Y, Z	2.5	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	60	mrad/s	
Typ. velocity X, Y, Z	2	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	30	mrad/s	
Mechanical properties			
Stiffness X, Y	0.1	N/µm	
Stiffness Z	4	N/µm	
Load (base plate horizontal / any orientation)	5 / 2.5	kg	max.
Holding force (base plate horizontal)	15	N	max.
Motor type	Brushless DC motor		
Miscellaneous			
Operating temperature range	0 to 50	°C	
Material	Stainless steel, aluminum		
Mass	1.7	kg	±5%
Cable length	2	m	±10 mm

Technical data specified at 20±3°C.
Ask about custom designs!
* The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_Z) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.



H-810, dimensions in mm

Controller for Hexapod Positioning Systems

6-D VECTOR MOTION CONTROL, COMPREHENSIVE FUNCTIONALITY

C-887

- Sophisticated controller using vector algorithms
- Freely programmable, virtual pivot point
- Data recorder
- Macro program functionality
- Stand-alone operation possible and control through TCP/IP and RS-232 interfaces
- Extensive software support

Digital controller for 6-axis-parallel kinematics

Included in the delivery of all PI standard Hexapod systems

- C-887.11, 19" controller, comprises the control for two additional single axes with servo motors, the functionality can be enhanced with many additional options
- C-887.21 compact bench-top controller for a lower system price

Extensive software support

Functions

Real-time system. Position control using Cartesian coordinates, vectorized motion. Stable, virtual pivot point can be defined freely in the working space. Data recorder for recording operating parameters such as motor control, velocity, position or position error. Macro command language. Stand-alone operation possible with Autostart macro or connection of keyboard and monitor. Optional: Manual control unit

Custom designs

Custom designs are available for use at high altitudes, e.g. for astronomical telescope applications. Processing of absolute sensors. Control of motor brakes. Processing of additional (redundant) position sensors for increased safety requirements, e.g. in medical technology

Software

PIMikroMove user software. Common command set for all PI positioning systems. Shared libraries for Windows and Linux. Complete set of LabVIEW VI's. Graphical user interfaces, configuration software and graphically displayed scan routine.
Optional: PIVeriMove software for checking a restricted operating space

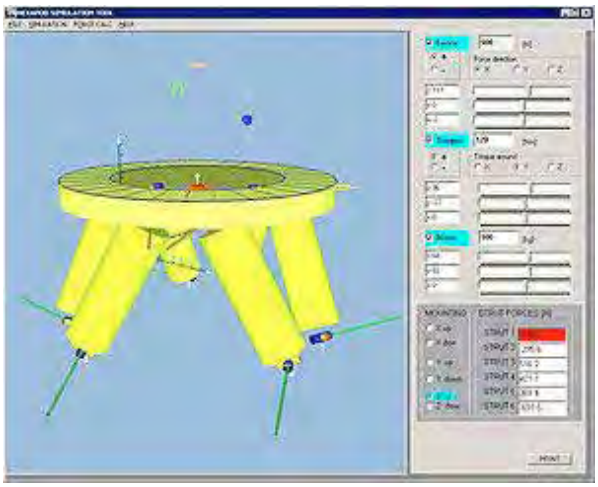
Interfaces

TCP/IP Ethernet can also be used for remote control and service, RS-232. Monitor, mouse and keyboard interface. On request: RS-422 for up to 1.4 km cable length

Possible enhancements for C-887.11

- Analog interfaces/photometer cards for visible light (F-206.VVU) or the infrared light range (F-206.iiU)
- F-206.NCU fast piezo nano-alignment system for alignment with nanometer precision

	C-887.11	C-887.21
Function	6-D controller for Hexapods, 19“, incl. control of two additional single axes, can be enhanced with many options	6-D controller for Hexapods, compact bench-top for a lower system price
Drive type	Servo motors (Hexapod and additional axes) Optional: Piezo drives	Servo motors
Motion and control		
Servo characteristics	32-bit PID filter	
Trajectory profile modes	Trapezoid, linear interpolation	
Processor	CPU: 1.8 GHz, motion control chip with 2.5 kHz servo update rate	
Encoder input	AB (quadrature) differential TTL signal, 5 MHz	
Stall detection	Servo off, triggered by position error	
Reference point switch	TTL signal	
Electrical properties		
Max. output power per channel	10-bit output for PWM drivers, 24 kHz	
Max. output voltage per channel	TTL in PWM operation for SIGN and MAGN	
Interface and operation		
Communication interfaces	TCP/IP, RS-232 VGA (monitor), USB (keyboard, mouse, manual control unit)	
Hexapod connection	MDR, 68-pin for data transmission M12 4-pin. for power supply	
Connection for additional single axes	15-pin sub-D	–
I/O ports	Optional: Analog inputs (photometer cards)	–
Command set	PI General Command Set (GCS)	
User software	PIMikroMove	
Software drivers	LabVIEW driver, shared libraries for Windows and Linux	
Manual control	Optional: C-887.MC control unit for Hexapods	
Miscellaneous		
Operating voltage	100 to 240 VAC, 50 / 60 Hz	
Operating temperature range	5 to 40°C	
Mass	11 kg	5 kg
Dimensions	395 × 483 × 185 mm	255 × 226 × 185 mm



All PI Hexapod systems are delivered with an extensive software package. Included are simulation programs that calculate the working space of the Hexapod and the individual loads on each actuator depending on the Hexapod orientation in space

Highly advanced digital controllers are also available for Hexapods with piezo stepping drives which are suitable for operation in strong magnetic fields or UHV environments

Hexapod-Specific Software

Due to their parallel kinematic structure, Hexapods necessitate a particularly complex control system. The position coordinates, for example, are given in virtual Cartesian axes which are then converted into positioning commands for the individual actuators by the controller. PI supplies special software that allow the 6-axes positioners to be more convenient in operation and easier to integrate.

Determining the work space

The limits of the work space vary depending on the current position of the Hexapod (translation and rotation coordinates) and the current coordinates of the pivot point. A special software tool included with each PI Hexapod calculates these limits and displays them graphically.

Checking the permissible load

As with any multiaxis positioning system, the load limit of the Hexapod varies as a function of a number of factors such as orientation of the Hexapod, size and position of the payload, current position (translation and rotation coordinates) of the Hexapod platform, and forces and moments acting on the platform.

The Hexapod software package includes a PI simulation tool that calculates all forces and moments and compares them individually against the specified load limits of the corresponding Hexapod mechanics.

Preventing collisions with PIVeriMove

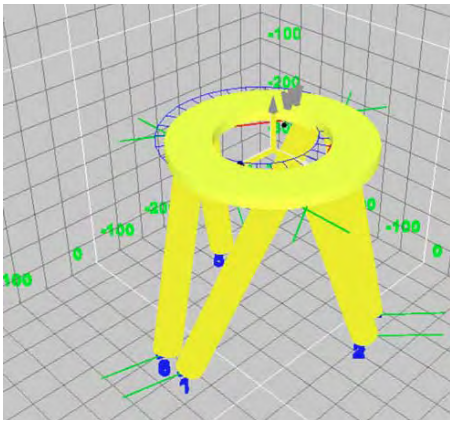
Another proprietary PI simulation software tool enables offline graphical configuration and simulation of the Hexapod motion in the application environment. CAD data of objects can be imported or approximated with simple shapes such as cylinders and cuboids. PIVeriMove then checks restrictions in the work space. Implemented in the controller firmware or the application software, this prevents the Hexapod from approaching positions where the platform, struts, or the mounted load would collide with the surroundings.

Emulation: The Hexapod system as a virtual machine

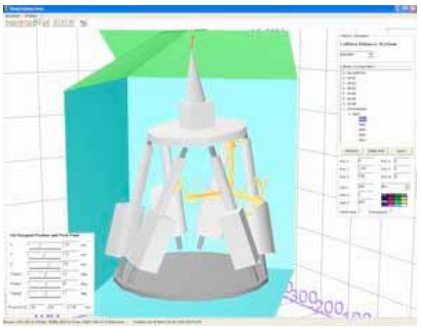
A virtual machine that can be installed on the customer's host PC is available to emulate a complete Hexapod systems (mechanics, controller and even peripherals). Application programs can then be developed and pre-tested, different load scenarios can be simulated and the work space can be determined before the system arrives, saving significant cost and development time.

HexaApp: PI Hexapod control via iPhone, iPad or iPod

The Hexapod system can also be controlled wirelessly from mobile Apple iOS devices. A corresponding app enables command control of touchscreen, motion sensors or via a command input window.



The simulation software graphically displays the position and the available work space of the Hexapod model



The M-810 was replaced by the H-810, see above

M-810 Miniature Hexapod

6 Degrees of Freedom & High Precision in a Small Package

The miniature Hexapod M-810 provides long travel ranges despite its compact design

- **Most-Compact Hexapod in the PI Portfolio**
- **Travel Ranges 40 x 40 x 13 mm, Rotation to 60 Degrees**
- **Load Capacity to 5 kg**
- **Resolution of a Single Strut 40 nm**
- **Min. Incremental Motion to 0.5 µm**
- **Repeatability up to ±0.5 µm**
- **Velocity to 10 mm/s**

With a platform diameter of only 10 cm the M-810 Hexapod is the most compact parallel-kinematics micropositioning system to date. In addition to positioning all six axes with high speed and accuracy, it allows the user to define the center of rotation (pivot point) anywhere inside or outside the system envelope by one simple software command. This makes it ideal for all complex positioning tasks with restricted space.

Application Examples

- Biotechnology
- Semiconductor technology
- Micromachining
- Micromanipulation
- X-ray diffraction measurements
- Tool control

Extremely Compact, Great Freedom of Motion

The M-810.00 with its direct-drive torque motors and ActiveDrive system with integrated servo amplifiers provides an increased velocity of up to 10 mm/s for loads up to 5 kg. Small and compact, the Hexapod allows a large stroke of up to 40 mm (linear) and 60° (angular).

Hexapod vs. Serial Kinematics Systems

The Hexapod is driven by six high-resolution actuators all connected directly to the same moving platform. This design provides a high system stiffness and a large clear aperture.

Because of the low mass of the moving platform, positioning operations can be performed with far lower settling times than with conventional, stacked multi-axis systems. In such systems, runout, guiding errors, and the friction and inertia of moving cables all accumulate to limit accuracy and repeatability-problems which do not affect parallel kinematic systems like the Hexapod.

User-Defined Pivot Point

For optics and other alignment tasks, it is important to be able to define a fixed pivot point. The sophisticated Hexapod-controller allows choosing any point in space as the pivot point for the rotation axes with a simple software command. The pivot point remains fixed relative to the platform.

Target positions in 6-space are entered in user-friendly coordinates and reached by smooth vectorized motion.

Ordering Information

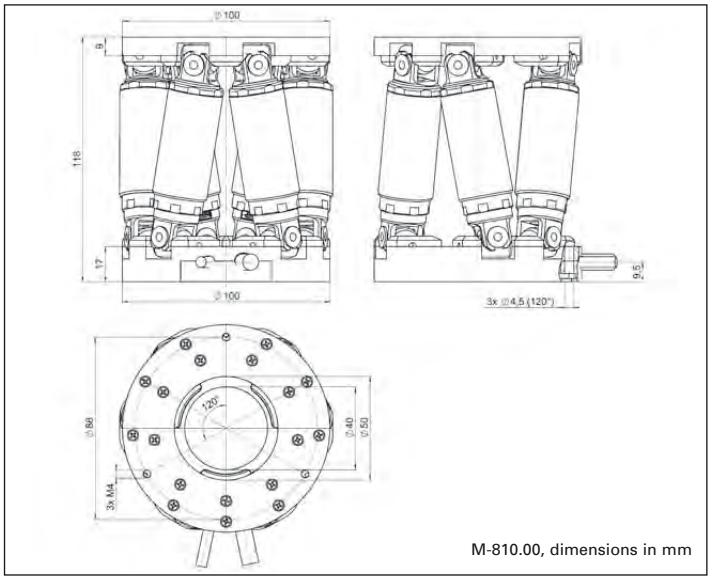
M-810.00
Miniature-Hexapod Microrobot with Controller, Direct Drive

M-810.0A
Miniature-Hexapod Microrobot with Controller, Direct Drive, Modified Cable Exit

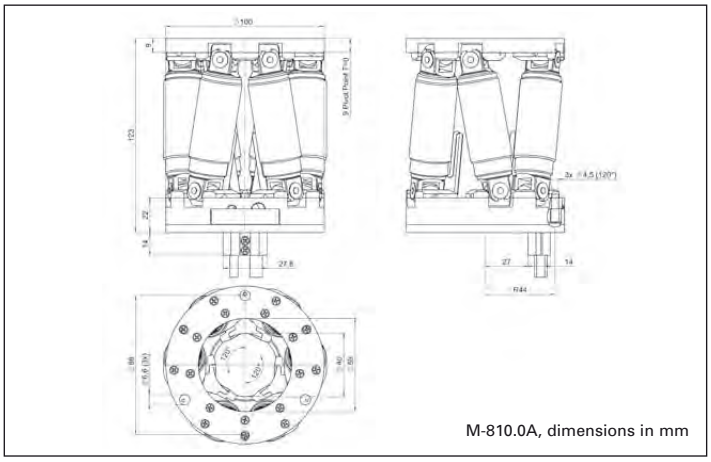
Ask about custom designs

Open Architecture

Control of the Hexapod is facilitated by the controller's open interface architecture, which provides a variety of high-level commands and includes a macro language for programming and storing command sequences.



M-810.00, dimensions in mm



M-810.0A, dimensions in mm

Technical Data

	M-810.00 / M-810.0A	Unit
Active axes	X, Y, Z, θX, θY, θZ	
Motion and positioning		
*Travel range X, Y	±20	mm
*Travel range Z	±6.5	mm
*Travel range θX, θY	±10	°
*Travel range θZ	±30	°
Actor drive	Brushless DC Motor, ActiveDrive	
Actuator stroke	±7.5	mm
Single-actuator design resolution	0.04	µm
Integrated sensor	Rotary encoder	
Sensor resolution	12800	Cts./rev.
**Min. incremental motion X, Y	1	µm
**Min. incremental motion Z	0.5	µm
**Min. incremental motion θX, θY, θZ	3.5	µrad
Repeatability X, Y	±2	µm
Repeatability Z	±0.5	µm
Repeatability θX, θY, θZ	±5	µrad
Backlash X, Y	2	µm
Backlash Z	0.5	µm
Max. velocity X, Y, Z	10	mm/s
Max. velocity θX, θY, θZ	250	mrad/s
Typ. velocity X, Y, Z	5	mm/s
Typ. velocity θX, θY, θZ	120	mrad/s
Mechanical properties		
Stiffness X, Y	0.1	N/µm
Stiffness Z	4	N/µm
Max. load (baseplate horizontal / any orientation)	5 / 2.5	kg
Miscellaneous		
Operating temperature range	0 to +50	°C
Material	Stainless steel, aluminum	
Mass	1.7	kg
Controller		
Operating Voltage	100–240 VAC, 50/60 Hz	

* The travel ranges of the individual coordinates (X, Y, Z, θX, θY, θZ) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.
** Six-axis move. No moving cables (unlike serial-kinematic stacked systems). Eliminates bending, inertia and friction, improving accuracy.
Technical data are specified at 20 ±3°C. Data for vacuum versions may differ.